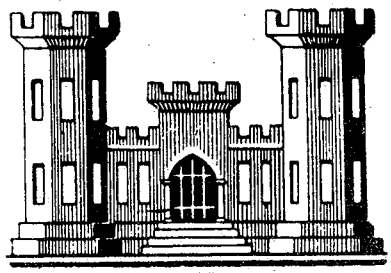
HYDROLOGIC REPORTING NETWORK PROJECT



# HYDROLOGIC REPORTING NETWORK

## NAUGATUCK RIVER BASIN

## DESIGN MEMORANDUM NO.1



U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS WALTHAM, MASS.

NOVEMBER 1963

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM 54. MASS.

ADDRESS REPLY TO:
DIVISION ENGINEER

REFER TO FILE NO.

NEDGB

12 November 1963

SUBJECT: Hydrologic Reporting Network, Naugatuck River Basin, Connecticut - Design Memorandum No. 1

TO: Chief of Engineers
ATTN: ENGCW-OS
Washington, D. C.

In accordance with EM1110-2-1150, there is submitted for information, Design Memorandum No. 1, entitled: "Hydrologic Reporting Network, Naugatuck River Basin". A request for frequency assignment will be forwarded by 15 November 1963.

FOR THE DIVISION ENGINEER:

John Wm Leslie

JOHN WM. LESLIE
Chief, Engineering Division

1 Incl (10 cys)
Design Memo No. 1

## TABLE OF CONTENTS



### TABLES



### DRAWINGS



### APPENDIX

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM 54, MASS.

# HYDROLOGIC REPORTING NETWORK

## DESIGN MEMORANDUM

October 1963

### 1. Purpose of Memorandum -

The proposal herein presents a plan for telemetering of hydrologic data in the Naugatuck River Basin.

### 2. Master Plan -

The installation presented in this memorandum is a test segment of a general plan for a hydrologic reporting network for the regulation of all New England Division reservoirs in five river basins. A description of the master plan is given in Appendix A.

### 3. Purpose of Network -

The general plan for a NED hydrologic radio reporting network for New England, as well as the initial test segment in the Naugatuck Basin, are necessary to insure proper operation of flood control reservoirs under adverse emergency conditions. Watershed control is achieved by numerous reservoirs on generally steep, narrow and flashy tributaries and requires precise operation for desynchronization. The systems must be designed to meet the prevalence of torrential type floods. Since New England floods are aseasonal, the flood control warning systems must operate effectively twelve months a year and especially during the hurricane season when hurricane winds can disrupt normal telephone communication systems.

### 4. Importance of Initial Test Segment -

The Naugatuck River Basin located in the western part of Connecticut has a drainage area of 312 square miles. The

watershed is generally elongated with a length of about 50 miles and an average width of about seven miles. Tributaries within the basin are relatively short and steep with no appreciable amount of valley storage. Because of the short steep tributaries and relatively narrow river valleys, floods develop very quickly. Analysis of past floods indicates that floods in the lower portion of the Naugatuck River have crested about six hours after cessation of heavy precipitation. It, therefore is imperative that a fast, reliable hydrologic network be established in the Naugatuck River basin to insure proper operation of flood control reservoirs.

5. Reservoir Regulation Procedures -

In the Naugatuck River basin, seven flood control reservoirs have been authorized. Five of these reservoirs are either constructed or under construction, while the remaining two are in final design. All the flood control dams are on tributaries with drainage areas less than 25 square miles except Thomaston Dam which controls 97.0 square miles of drainage area. Four of the dams will be ungated and will act as retarding basins desynchronizing flood flows. Upon instructions from the Reservoir Regulation Section, gate regulation at the remaining three dams will be accomplished by a revolving team under the supervision of the Thomaston Flood Control Dam Operator.

Regulation at Thomaston Dam will be governed by:

a. Precipitation amounts reported in the basin.

b. Events taking place at the other flood control reservoirs.

c. River stages at key locations along the Naugatuck River.

The hydrologic radio network will provide, by the most reliable means available, the basic information required for proper operation of the flood control reservoirs in the Naugatuck River basin. Rainfall data received from the radio gage at the relay station together with rainfall recorded at Thomaston Dam will be used to appraise the storm potential and alert personnel to man the two other gated flood control dams. Pool elevation data will be used to compute inflow and outflow from each reservoir and thus locate the area of concentrated runoff. Releases

at the gated reservoirs will be coordinated with outflows computed from the ungated reservoirs. River stage data will be used to adjust the regulation to provide optimum effectiveness of the entire system. Table I lists pertinent data for each radio gage and location of each radio gage is shown on Sketch No. R-1.

The operator at Thomaston Dam will supervise the regulation of all reservoirs in the Naugatuck River basin under the direction of the Reservoir Regulation Section. The hydrologic radio network will be controlled by the FCDO at Thomaston Dam during off duty hours, with reports to RRS at their homes whenever required according to instructions listed in the Regulation Manual. Interrogation of the entire network will be made by the Operator before contacting RRS during off duty hours.

During regular working hours and whenever the office personnel is mobilized for flood emergencies, the control of the network will be by RRS at NED Headquarters. Read-out of the hydrologic data will be made at both NED and Thomaston Dam. Although Mad River Dam, an unattended and ungated reservoir, is located in the Farmington River watershed (Connecticut River basin), the radio pool gage will be included in the Naugatuck network until Colebrook River Reservoir is completed. The Mad River watershed is adjacent and similar to the small tributary watersheds in the Naugatuck River basin. Because of its proximity to Thomaston Dam, the information will be included in the Naugatuck Radio Network. The Mad River Dam information will be transmitted to Colebrook River Dam upon its completion.

Cooperation With Other Agencies -

NED has received verbal approval from the U. S. Geological Survey for the installation of radio equipment at their gaging stations. Data from the Hydrologic radio network will be made available to U. S. Weather Bureau's River Forecasting Center at Windsor Locks, Connecticut.

6. Flood Control Dams -

a. Hall Meadow Brook Dam

TABLE I

PERTINENT DATA FOR PROPOSED RADIO GAGES

| Radio Gage | Scheduled Year of Installation | Drainage Area (sq.mi.) | Storage (ac/ft) | Capacity (inches) | Gated | Ungated |
|---|---|---|---|---|---|---|
| **Reservoirs** | | | | | | |
| Thomaston Dam | 1964 | 97.0 | 42,000 | 8.1 | X | |
| Hall Meadow Brook | 1964 | 17.2 | 8,410 | 9.2 | | X |
| East Branch | 1964 | 9.25 | 4,350 | 8.9 | | X |
| Northfield Brook | 1965 | 5.70 | 2,350 | 7.7 | | X |
| Hancock Brook | 1965 | 12.0 | 3,900 | 6.1 | | X |
| Hop Brook | 1966 | 16.1 | 6,840 | 8.0 | X | |
| Black Rock | 1966 | 20.8 | 8,860 | 8.0 | X | |
| Mad River | 1964 | 18.2 | 9,700 | 10.0 | | X |
| **Precipitation** | | | | | | |
| Goshen | 1964 | | | | | |
| **River** | | | | | | |
| Beacon Falls (U.S.G.S.) | 1964 | 261 | | | | |
| Waterbury | 1966 | 178 | | | | |
| Stevenson (U.S.G.S.) | 1966 | 1545 | | | | |

(1) Description -

Hall Meadow Brook Dam is an unattended and ungated dam which is operated for flood control in conjunction with two local protection projects in Torrington and the East Branch Reservoir. Major discharge reductions are provided to the communities of Torrington, Harwinton and Litchfield. The reservoir has a capacity of 8,620 acre-feet, equivalent to 9.4 inches of runoff from its drainage area of 17.2 square miles.

(2) Location -

This dam is located on Hall Meadow Brook about 0.4 miles above its confluence with Hart Brook to form the West Branch of the Naugatuck River and about 5 miles upstream of the City of Torrington. The project was completed in 1962.

(3) Present Installation -

Reservoir stages are recorded by a digital recorder (Fisher and Porter Analog - to Digital Recorder, ADR) driven by a bubble gage, and housed in a concrete shelter on top of the dam.

(4) Modification Needed -

A radio transmitter will be connected to the digital recorder. The pool stages will be used to compute the reservoir inflow and outflow.

b. East Branch Dam -

(1) Description -

East Branch Dam is an unattended and ungated dam which is operated for flood control similar to Hall Meadow Brook Dam. At spillway crest, East Branch Reservoir has a storage capacity of 4,350 acre-feet, equivalent to 8.9 inches of runoff from drainage area of 9.25 miles.

(2) Location -

This dam is located on the East Branch of the Naugatuck River about 2.5 miles upstream from the center of

Torrington. The dam is presently under construction and is scheduled to be operational in 1964.

(3) Present Installation -

Reservoir stages will be recorded by a digital recorder driven by a bubble gage, and housed in a concrete shelter on top of the dam.

(4) Modification Needed -

A radio transmitter will be connected to the digital recorder. The pool stages will be used to compute the reservoir inflow and outflows.

c. Thomaston Dam

(1) Description -

Thomaston Reservoir has a capacity of 42,000 acre-feet, equivalent to 8.1 inches of runoff from its drainage area of 97 square miles. Outflow from the dam is controlled by two mechanically operated flood gates located in a gate tower. Regulation at this project will be coordinated with four other downstream flood control reservoirs to reduce flood damages along the Naugatuck River.

(2) Location -

This dam is located on the Naugatuck River 30.4 miles above the confluence of the Naugatuck and Housatonic Rivers, and 1.6 miles north of Thomaston. The project was completed in 1960.

(3) Present Installation -

An existing audio radio unit is located in the utility building. The pool recorder consists of a Stevens A-35 analog recorder which is operated by a Stevens Surface Detector located over a 4-inch float well in the gate tower.

(4) Modification Needed -

The system's interrogation and read-out unit will be located in the utility building. A radio transmitter will

also be connected to the digital pool recorder at the Thomaston Reservoir.

d. Northfield Brook Dam -

(1) Description -

Northfield Brook Dam is an unattended and ungated dam. At spillway crest, the flood control storage is 2,430 acre-feet, equivalent to eight inches of runoff from its drainage area of 5.7 square miles.

(2) Location -

This dam is located on Northfield Brook approximately 1.3 miles upstream from its confluence with the Naugatuck River in the town of Thomaston. The dam is presently under construction and scheduled to be in operation in 1965.

(3) Present Installation -

Reservoir stages will be recorded by a digital recorder driven by a bubble gage, and housed in a concrete shelter on top of the dam.

(4) Modification Needed -

A radio transmitter will be connected to the digital recorder.

e. Hancock Brook Dam -

(1) Description -

Hancock Brook Dam is an unattended and ungated dam. The reservoir has a capacity of 3,820 acre-feet equivalent to 6.0 inches of runoff from its drainage area of 12 square miles.

(2) Location -

This dam is located on Hancock Brook in the town of Plymouth, Connecticut, about 3.4 miles above its confluence with the Naugatuck River. The dam is presently under construction and is scheduled to be operation in 1965.

(3) Present Installation -

Reservoir stages will be recorded by a digital recorder driven by a bubble gage, and housed in a concrete shelter on top of the dam.

(4) Modification Needed -

A radio transmitter will be connected to the digital recorder.

f. Mad River Dam -

(1) Description -

Mad River Dam is an unattended and ungated dam. The reservoir has a capacity of 9,700 acre-feet equivalent to 10 inches of runoff from its drainage area of 18.2 square miles. Although this dam is located in the Farmington River watershed of the Connecticut River Basin, the Mad River gage will be included in the Naugatuck radio network.

(2) Location -

This dam is located on Mad River in the Town of Winchester, Connecticut, about 2.3 miles above the confluence with the Still River and about 0.3 miles upstream of the westerly city limits of Winsted. The project was completed in 1963.

(3) Present Installation -

Reservoir stages will be recorded by a digital recorder driven by a bubble gage, and housed in a concrete shelter on top of the dam.

(4) Modification Needed -

A radio transmitter will be connected to the digital recorder.

g. Hop Brook Dam -

(1) Description -

Hop Brook Reservoir will have a capacity of 6,840 acre-feet, equivalent to 8 inches of runoff from its drainage area of 16 square miles. Outflow from the dam will be controlled

by two mechanically-operated flood gates located in a gate tower. One member of the revolving team of personnel assigned to Thomaston Dam will reside in the vicinity of Middlebury, Connecticut, and will operate the gates during flood emergencies.

(2) Location -

This dam will be located on Hop Brook in Middlebury about 1.3 miles upstream from its confluence with the Naugatuck River. The project is presently in final design.

(3) Present Installation -

The pool recorder will be a float-operated digital recorder located in the gate tower.

(4) Modification Needed -

A radio transmitter will be connected to the digital recorder.

h. Black Rock Dam -

(1) Description -

Black Rock Reservoir will have a capacity of 8,860 acre-feet, equivalent to 8 inches of runoff from its drainage area of 20.8 square miles. Outflow from the dam will be controlled by two mechanically-operated flood gates located in a gate tower. One member of the revolving team of personnel assigned to Thomaston Dam will reside close to Black Rock Dam and will operate the gates during flood emergencies.

(2) Location -

This dam will be located on Branch Brook, about 1.8 miles upstream of its confluence with the Naugatuck River in Thomaston, Connecticut. The project is presently in final design.

(3) Present Installation -

The pool recorder will be a float-operated digital recorder located in the gate tower.

(4) Modification Needed -

A radio transmitter will be connected to the digital recorder.

7. Stream Gaging Stations -

a. Naugatuck River at Beacon Falls, Connecticut -

(1) Description -

The Naugatuck River at Beacon Falls, Connecticut is the site of a USGS operated stream gaging station. This gage has been in operation since 1 October 1955. From 1928 to August 1955, the gage was located 2.5 miles upstream of the present location but was destroyed during the August 1955 flood. This gage is a primary index point for the regulation of Naugatuck River basin flood control reservoirs.

(2) Location -

On left bank at downstream side of Bridge Street highway bridge at Beacon Falls, Connecticut.

(3) Present Installation -

A Stevens type A-35 water level recorder operated by a standard 35-foot range bubble gage which also operates a Stevens T-3 telephone Telemark including a disabling switch. The gage house has no basement or stilling well.

(4) Modification Needed -

A digital recorder will be operated by the existing bubble gage which will also continue to operate the A-35 Recorder at the request of the USGS.

b. Naugatuck River at Waterbury, Connecticut -

(1) Description -

The present site is at the American Brass Company in the vicinity of a potentially high damage center. The gage has a computed rating.

(2) Location -

In American Brass Company power house.

(3) Present Installation -

A Bristol Recorder of the diaphragm pressure type.

(4) Modification Needed -

The existing gage is unsuitable. A new 35-foot range bubble gage with digital recorder adapted for radio transmission is needed. It will be located either in the ABC power house or city of Waterbury sewage treatment plant. A more reliable discharge rating will be developed for this site.

c. Housatonic River at Stevenson, Connecticut -

(1) Description -

This station has been operated continuously by the USGS since 1928 and is the most reliable downstream gage on the Housatonic River above the confluence with the Naugatuck River. The maximum discharge of record is 75,800 cfs in October 1955.

(2) Location -

The gage is located on the left bank 0.2 miles downstream of CL&P Company dam at Stevenson, Connecticut.

(3) Present Installation -

Stevens Type A-35 water level recorder, float-operated in a 5' x 5' reinforced concrete stilling well shelter. A remote recorder is located in the CL&P dam.

(4) Modification Needed -

A float-operated digital recorder adapted for radio transmission would be added.

8. Precipitation Gaging -

A reporting precipitation gage will be provided at the Goshen relay station and will be connected directly into the hydro-

logic reporting network without the need for a separate radio transmission link. Reports from this station in conjunction with reports from other NED and USWB installations will be used to evaluate the flood potential of each storm. During the snow season, surveys will be made at key index points throughout the basin to evaluate the water content of the snow pack. As a result, the precipitation gaging and keying unit will have to measure only accumulated precipitation at the site and not snowfall.

9. Recommended Transmission Links -

It is recommended that FM VHF and/or UHF radio links be used to provide the required transmission medium for the initial test segment of the comprehensive hydrologic reporting network for the New England Division reservoirs. The use of radio telemetering offers the following advantages:

a. The initial test segment will facilitate the gaining of valuable engineering and operating experience by the New England Division in radio telemetering.

Unattended programed automatic operation becomes an important factor considering the detailed monitoring required of reporting stations in the initial test segment as presented in paragraph 3, and will be a "must" considering the overwhelming volume of hydrologic data which will ultimately be handled by the comprehensive network.

b. VHF/UHF radio links, when backed up by emergency power are more reliable than wire lines due to the vulnerability of wire lines to weather. Weather hazards increase during seasons when reports may be most needed. Although reporting stations connected to regular message telephone networks offer the advantage that they may be interrogated by placing a telephone call from any location equipped with a utility telephone, such operation cannot be depended upon for interrogating the stations and obtaining readings at the desired frequency during flood emergencies.

c. Radio facilities within the initial test segment, such as radio-equipment buildings, antenna towers, and commercial and standby power, can provide a ready means and flexibility for handling at moderate cost, radio telemetering or communication requirements that may arise in the future. A possible future application would be radio telemetering of radio active fallout radiation levels.

10. System Operation -

The telemetering system will be of the "interrogating" type with reports obtainable from reporting stations at all times on an "on-call" basis and with the hydro read-out stations located at Thomaston Dam and at Ned Headquarters. The hydro read-out stations will be equipped with a manual interrogation panel to permit selective, manual interrogation of reporting stations on an attended basis and the manual interrogation panel will be supplemented with an automatic programing and timing panel to provide automatic interrogation of reporting stations at regular preset intervals on an unattended basis. All incoming reports will be recorded in typed form. Each gage will be interrogated separately by selective tone code.

a. A detailed operational plan is as follows:

Operational Plan for Hydrological Data
Reporting Tie to NED Radio Network

(1) The hydro read-out station at Thomaston Dam (or NED Headquarters) will transmit a coded tone interrogation to the Goshen Relay.

(2) Automatically triggering Goshen hydro channel transmitter and transmitting interrogation signal to gaging station.

(3) Automatically triggering properly coded gaging station, turning on gage transmitter, and requesting gage reading.

(4) Automatically, (after a 1-minute time delay for transmitter warm-up) gage transmitter will return coded hydro data to Goshen hydro channel receiver.

(5) Automatically triggering Goshen hydro channel transmitter and transmitting coded hydro data to Thomaston Dam.

(6) Automatically, the read-out equipment at Thomaston will decode the coded hydro data and produce a typed digital record indicating date, time, gage number and gage reading.

(7) Simultaneously with Step 5, Goshen relay 400 mc transmitter will be triggered, transmitting the coded hydro data through Wachusett relay (on NED audio channel B) to NED headquarters at Waltham.

(8) Automatically, the read-out equipment at Waltham will decode the coded hydro data and produce a type digital record indicating date, time, gage number and gage reading.

11. Network Arrangement -

Radio signal paths presented in this design memorandum for reporting stations located in the Naugatuck River Basin are based upon the installation of a VHF repeater station in the existing Goshen relay station and make use of one multiplex channel of the New England Division UHF/VHF radio network for the reaches into Thomaston Dam and NED Headquarters. Preliminary radio-propagation tests conducted by First U. S. Army Signal Corp prior to the erection of the existing 260 foot tower at Goshen, using a trailer-mounted 50-foot crank-up mast at Goshen and mobile VHF units at the approximate locations of the gaging sites indicate that dependable radio signal paths can be established using conventional VHF equipment.

12. Equipment Arrangement -

a. Stream Stage (or Pool) Reporting Stations -

Equipment will be housed in existing structures and will consist of radio telemetering unit, water-level gaging unit, keying unit and power supply. The antenna will be located as near to the existing structures as practical and will generally be mounted on 40-foot masts.

b. Repeater Station -

Radio equipment will be housed in the existing Goshen relay building and will consist of a VHF repeater station. Antenna will be mounted on the existing 260-foot tower. See Sketch Nos. G3 and G4.

c. Hydro Read-Out Station -

Radio equipment is existing and is presently housed in existing structures at both Thomaston Dam and at NED Headquarters. Read-out equipment and interrogation equipment will be mounted adjacent to existing radio equipment.

13. Equipment Choice and Miscellaneous Comments: -

a. Power Supply for Gaging Stations -

It is planned to have all radio telemetering equipment for reporting stations designed or equipped solely for d-c operation from local storage-battery power and to use 120 volt, a-c, 60-cycle commercial power for battery charging where it is readily available. This system will provide emergency operation in case of commercial-power failure without the need for automatic switch-over equipment and additional power supplies. The battery charger will be of the automatic type which, regardless of continuous "stand-by" receiving loads and intermittent "transmit" loads on the battery, can keep the battery fully charged ready to furnish emergency power at all times in case of commercial-power outage. Transistorized equipment as proposed in subparagraph 13.d., will alleviate the problem of providing sufficient ampere-hour storage battery capacity for extended emergency operation. Since year around operation is contemplated and batteries will be kept on a constant charge, it is proposed to use lead-acid type batteries as an economy measure.

b. Power Supply for Goshen Relay, Thomaston Dam and NED Headquarters -

All existing radio equipment in these facilities now operates from 120-volt, a-c, 60 cycle commercial power and each facility is provided with diesel-engine driven emergency generators. Automatic starting and automatic transfer are provided at Goshen relay only. Each of the other facilities will be manned during normal work hours and emergency periods.

c. Tone and Service Channels -

Selective tone equipment, multiplexed to operate in the audio pass band of the FM-VHF/UHF radio equipment, will provide the necessary channels for independent interrogating and telemetering functions over the FM-VHF/UHF radio circuits. In addition, the hydrologic system will provide a voice communication service channel for installation, maintenance, and emergency purposes only.

d. Transistorization -

Transistorized radio, tone, and station-control equipment of the latest design will be utilized to the greatest available

extent in all stations to increase station reliability, to reduce power consumption. The reduction of power consumption will be of most benefit in reporting stations by minimizing storage-battery drain when the stations are on "stand-by" operation (receiving - not transmitting) which is the prevailing condition of operation.

e. Station Identification and Recorder Operation -

Each data collection center will be equipped with a recorder to permit unattended programed operation. Since only one recorder will be used at a center for this segment, a record of the date and time of data receipt and of reporting station identification will accompany each recording for unattended programed operation.

f. Gaging and Keying Units -

(1) The gaging and keying unit should be capable of low-drain d-c operation from a battery source. Gaging and keying units requiring a 120-volt, a-c, 60 cycle power source and the recorder in the hydro read-out station to be connected to the same electrical system for maintaining synchronized operation will not be used. A telemetering system utilizing such equipment is vulnerable to power outages. In addition, such units are not compatible with recorders offering more standard operation and cannot be used in the comprehensive network for reporting stations located in regions where commercial power is not available and where battery type of operation must be resorted to.

(2) An encoding device that will be considered for use in the test segment as a gaging and keying unit is the Fischer & Porter Analog to Digital Recorder (ADR), manufactured by the Fischer & Porter Company of Hatboro, Pennsylvania or an equivalent unit manufactured by General Electric. It is understood that this device has been approved by the U. S. Geological Survey Department for stream and river level measurement in remote spots throughout the United States. Also, that a weighing-type rain gage is available for use in conjunction with this device.

14. Recommended Construction Method -

a. Procure by supply contract water level gaging and keying units, a precipitation gaging and keying unit, and associated accessories and basic controls for reporting stations and compatible recorders for the data collection center stations, with the exception

that the recorders may be included in the radio-telemetering system contract described under subparagraph b. below.

b. Award a construction contract for furnishing, constructing and installing all radio telemetering facilities required for the segment, such as service entrances, electric wiring, storage batteries, aerial or underground remote control lines and antenna towers. The contract will include the installation of Government-furnished gages with their accompanying gaging and keying units (obtained under subparagraph 14a above) in existing buildings.

c. Or award a construction contract combining the requirements of both paragraphs a. and b.

15. Estimated Initial Costs -

a. Current Estimate -

The current estimate presented in Table 2 below shows the total estimated cost for this test segment to be $75,000. The estimate is arranged to reflect the cost divisions by the types of equipment involved and is further divided to show the cost of each station, and the fiscal year of the initial and later segments.

b. Assumptions and Field Problems -

A preliminary estimate for any field project involving several installations in diversified locations is always susceptible to unforeseen field problems. The contemplated project is especially vulnerable to such problems since geographic factors of finally selected radio sites have the potential of influencing, either adversely or favorably, final costs of pertinent facilities. However, the preliminary estimate presented above for the initial cost of the segment is considered sufficiently reliable for purposes of this memorandum.

c. Changes Due to Field Problems and Technological Advances -

From the discussion in subparagraph 15.b. above, it is readily understandable that, at the present state of planning for the purpose of this design memorandum, the final design and type of installation for pertinent field facilities may be subject to necessary changes from the plans presented herein due to unforeseen field conditions. It is also considered and proposed that the details presented herein for the radio telemetering system should impose no restrictions

## ESTIMATED CONSTRUCTION COST

TABLE II

| LOCATION | Gaging Equipment and/or Connections to Tone Keying | Tone Keying | VHF Radio Equipment | Power Supply | Inter & Read-Out | Contingency | Engineering, Supv. & Admin. | TOTAL |
|---|---|---|---|---|---|---|---|---|
| Goshen Relay & Precip. Gage | 450 | 1850 | 1650 | | | 400 | 500 | 4850 |
| Thomaston Dam | *100 | | 1350 | | | 1060 | 1150 | 12660 |
| Hall Meadow Dam | * 50 | 1850 | 1350 | 350 | 9000 | 400 | 440 | 4440 |
| East Branch Dam | * 50 | 1850 | 1350 | 350 | | 400 | 440 | 4440 |
| Mad River Dam | * 50 | 1850 | 1350 | 350 | | 400 | 440 | 4440 |
| Beacon Falls River Gage | * 50 | 1850 | 1350 | 350 | | 400 | 440 | 4440 |
| 1964 Sub Total | 750 | 9250 | 8400 | 1400 | 9000 | 3060 | 3410 | **35270 |
| Northfield Brook Dam | * 50 | 1850 | 1350 | 350 | | 400 | 440 | 4440 |
| Hancock Brook Dam | * 50 | 1850 | 1350 | 350 | | 400 | 440 | 4440 |
| 1965 Sub Total | 100 | 3700 | 2700 | 700 | | 800 | 880 | 8880 |
| Hop Brook Dam | * 50 | 1850 | 1350 | 350 | | 400 | 440 | 4440 |
| Waterbury River Gage | 450 | 1850 | 1350 | 350 | | 400 | 440 | 4840 |
| Stevenson Dam | 450 | 1850 | 1350 | 350 | | 400 | 440 | 4840 |
| Black Rock Dam | * 50 | 1850 | 1350 | 350 | | 400 | 440 | 4440 |
| NED Hdqtrs | | | | | 9000 | 900 | 1000 | 109000 |
| 1966 TOTAL | 1000 | 7400 | 5400 | 1400 | 9000 | 2500 | 2760 | 29460 |
| T O T A L | 1850 | 20,350 | 16,500 | 3,500 | 18,000 | 6,360 | 7,050 | $73,610 |
| | | | | | | | | SAY: |
| | | | | | | | | $75,000 |

* Gaging equipment existing or by others

** Cost of initial segment

or changes to the final system design and equipment choice when such changes due to advances in technology offer advantageous factors such as easier installation, less complexity, superior or more reliable operation and easier or less-frequent maintenance with no resultant increase in initial or annual cost to the Government.

16. Estimated Annual Costs -

The cost of this test segment has been amortized at 2-1/2 percent interest over a period of 20 years which has been assumed as an average period between buildings and similar facilities which usually have a longer useful life and equipment which, largely because of obsolescence, may have a shorter useful life. The total annual costs of this test segment, based upon the foregoing fixed costs of capital and upon operation and maintenance costs, are shown in Table 4 below.

TABLE 4

Estimated Annual Costs

| | | |
|---|---|---|
| **Fixed Costs** (of Government Capital investment - $73,610) | | |
| Interest @ 2.5% | $1,816 | |
| Amort. 2.5%, 20 years (0.039147) | 2,837 | |
| | | $4,653 |
| **Operation and Maintenance Costs** | | |
| Equipment O&M Materials: | | |
| Radio Equipment | 240 | |
| Gaging, Keying & Recording Equipment | 150 | |
| Radio Maintenance, Labor and Mileage | 1,500 | |
| * Obstruction Lighting Maintenance (Twice per yr) | 0 | |
| Government Inspection, Gaging & Keying: | | |
| Equip. Maintenance and Mileage | 500 | |
| * Emergency Generator O&M (Relay Station) | 0 | |
| * Commercial Power: | | |
| 8 Reporting Stations | 960 | |
| Relay Station | 0 | |
| * Buildings, Towers & Grounds | 500 | |
| | | $3,850 |
| Total Estimated Annual Cost of Segment | | 8,503 |

* Since all stations in this proposed test segment will be located on existing Government facilities, with the exception of Beacon Falls, Waterbury and Stevenson Dam, only such costs that would not normally be charged to the operation and maintenance of existing facilities is chargeable to this proposal.

18. Pertinent Radio Network Data -

The data presented in Table 3 below is submitted to comply with EM-1110-2-3600, paragraph 5-08-C pursuant to assignment of frequencies and call letters for the proposed segment. See Sketch No. R-1 and NED Radio Network Map.

19. Recommendations -

The Naugatuck Basin hydrologic reporting network actually constitutes a test segment and a pilot network for a comprehensive hydrologic reporting network for the regulation of the New England Division Reservoir System. Under this criterion, it is proposed to investigate and utilize in this test segment advanced equipment developments and techniques, including the use of transistorized radio-telemetering equipment and the use of a gaging and keying unit compatible to the operation of the comprehensive network with its ultimate high data-handling requirements. It is therefore recommended that approval be given for the installation of the network, consisting of the six (6) initial reporting stations, with provisions for the future addition of six (6) reporting stations to the network as discussed herein.

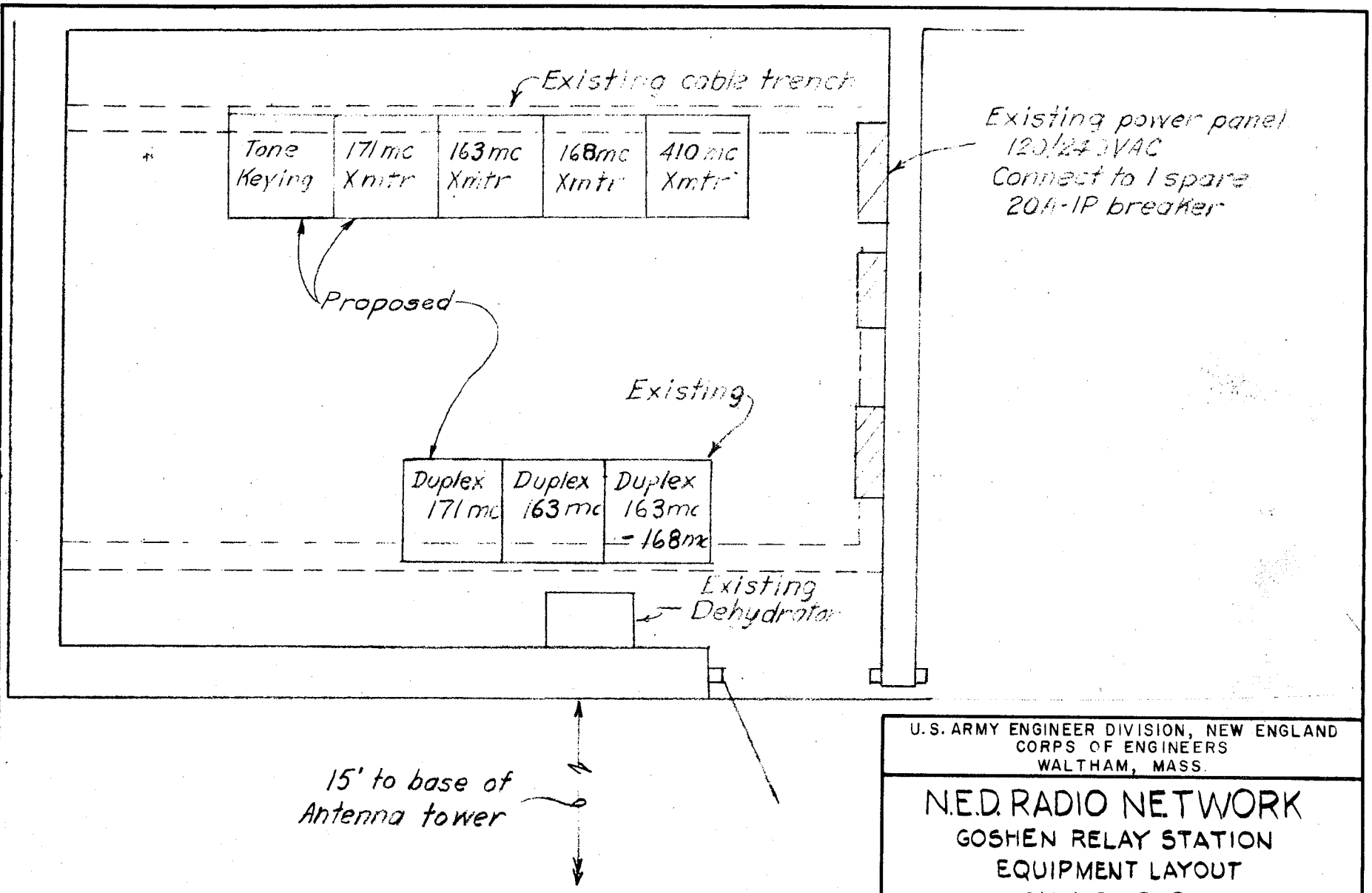
TABLE III

NAUGATUCK HYDROLOGICAL DATA TIE TO NED RADIO NETWORK

| Facility | Lat. | Long. | Freq. | Call Sign | Output Watts | Data | Operation Schedule | Emission |
|---|---|---|---|---|---|---|---|---|
| Goshen Relay | 41-52-38 | 73-12-22 | T-412.950 | WUA 44 | 100 | Audio & Hydro | On Call | 50F9 |
| Goshen Relay (Repeater) | 41-52-38 | 73-12-22 | * | * | 60 | Hydro | ** | 16F2 |
| Thomaston Dam (Hydro read-out station) | 41-41-45 | 73-03-40 | * | WUA 26 | 60 | River Stage | ** | 16F2 |
| Hall Meadow Brook Dam | 41-52-10 | 73-10-00 | * | * | 30 | " | ** | 16F2 |
| East Branch Dam | 41-50-10 | 73-07-10 | * | * | 30 | " | ** | 16F2 |
| Northfield Brook Dam | 41-40-50 | 73-05-25 | * | * | 30 | " | ** | 16F2 |
| Hancock Brook Dam | 41-37-20 | 73-02-15 | * | * | 30 | " | ** | 16F2 |
| Mad River Dam | 41-55-55 | 73-05-30 | * | * | 30 | " | ** | 16F2 |
| Waterbury | 41-32-30 | 73-02-25 | * | * | 30 | " | ** | 16F2 |
| Beacon Falls | 41-26-35 | 73-03-50 | * | * | 30 | " | ** | 16F2 |
| Stevenson Dam | 41-23-00 | 73-10-20 | * | * | 30 | " | ** | 16F2 |
| Hop Brook Dam | 41-31-00 | 73-03-40 | * | * | 30 | " | ** | 16F2 |
| Block Rock Dam | 41-39-26 | 73-06-13 | * | * | 30 | " | ** | 16F2 |

* Frequency and call sign to be assigned - Proposed frequencies 171.025 _ 169.450 mc.

** On Call - By tone code interrogation from hydro read-out station with a normal duty cycle of one (1) call per day or a flood emergency duty cycle of one call per 15 minutes for a maximum of one week.




U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

# N.E.D. RADIO NETWORK

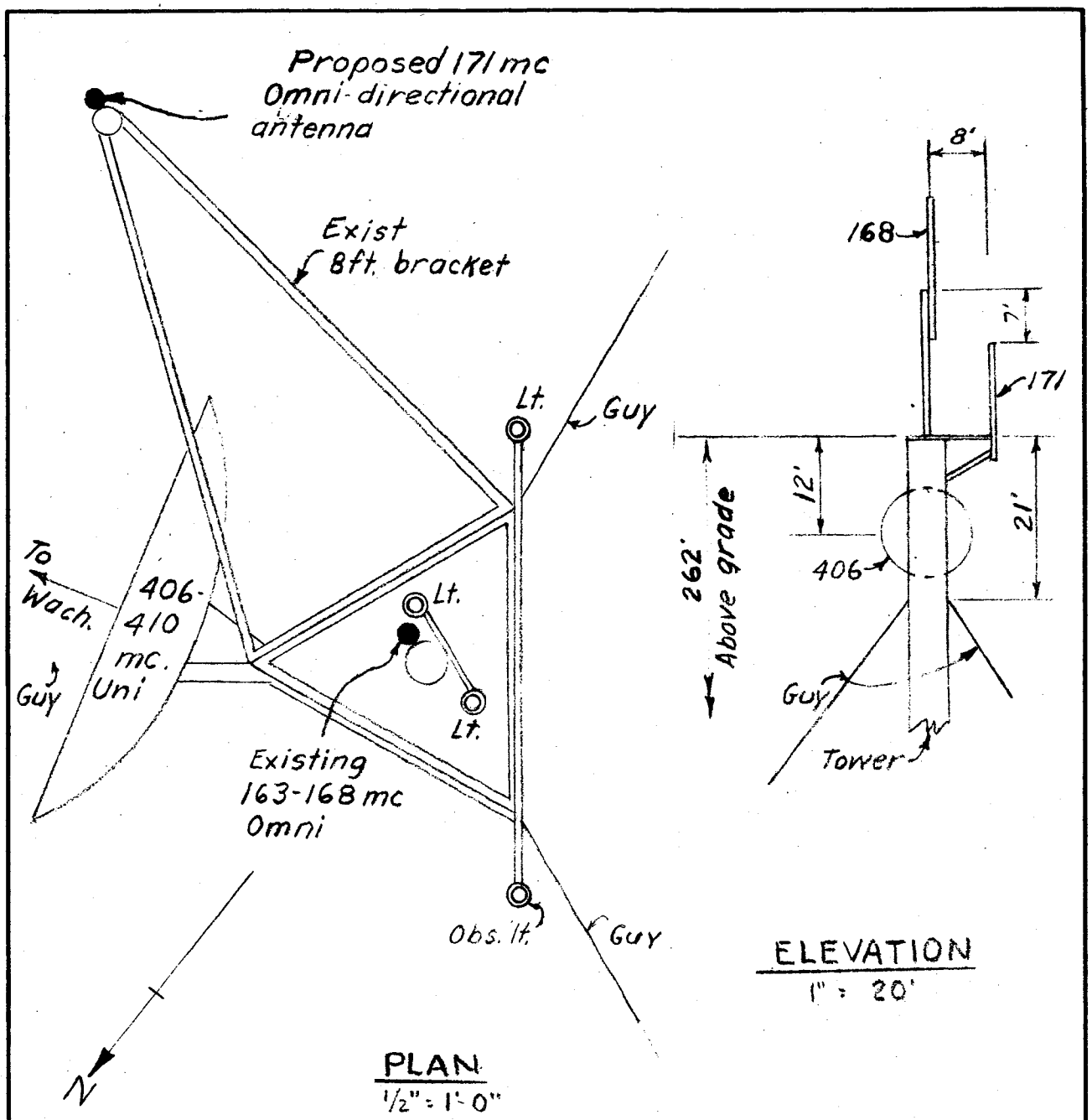
## GOSHEN RELAY STATION

## EQUIPMENT LAYOUT

## SK. NO. G-3

SCALE: 3/8" = 1'-0" DATE: MAY 10, 1963

SK NO. G-3




U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

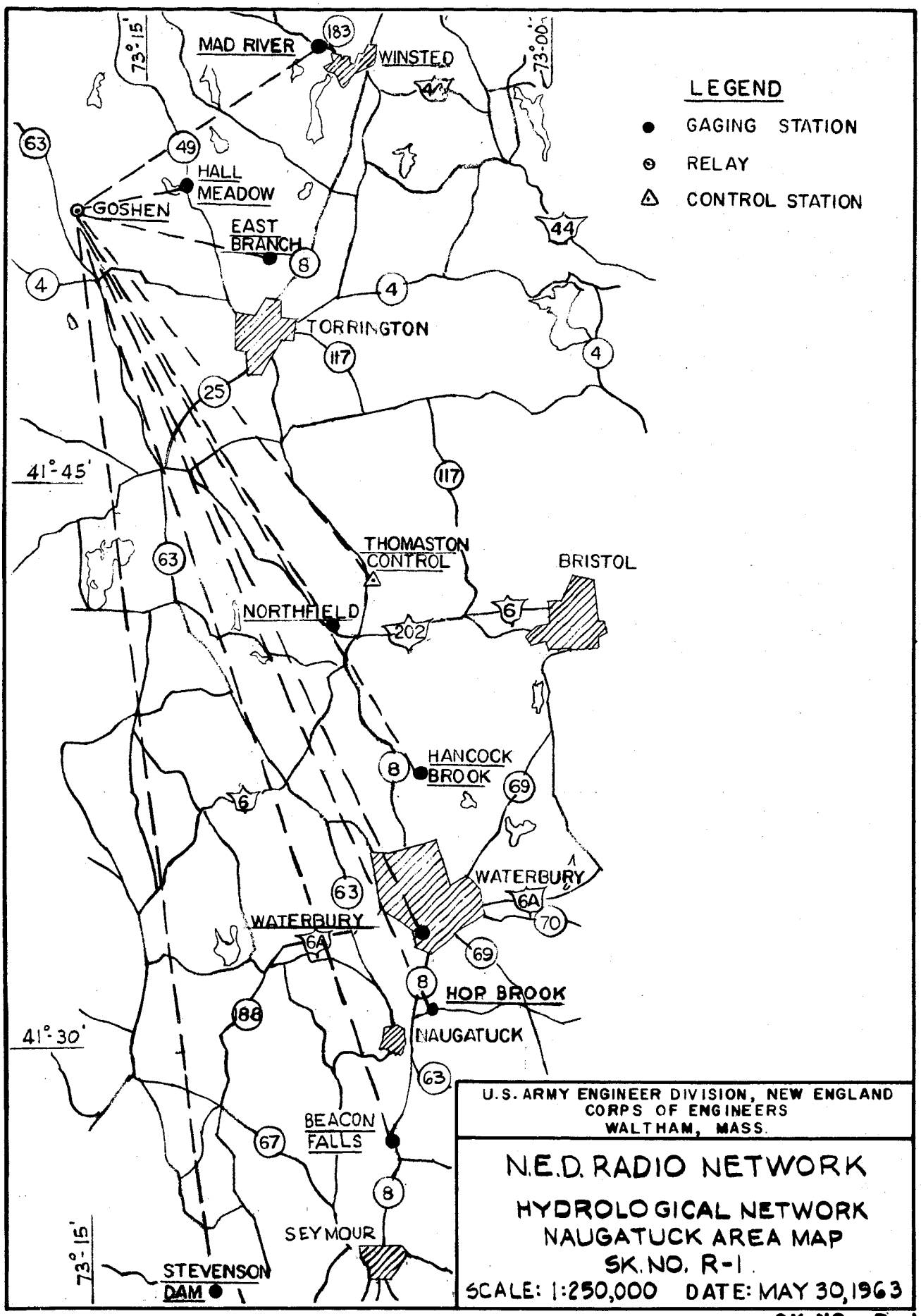
# N.E.D. RADIO NETWORK

## GOSHEN RELAY STATION
## ANTENNA LAYOUT

SK. NO. G-4

SCALE AS SHOWN DATE: OCT. 1963

SK NO. G-4



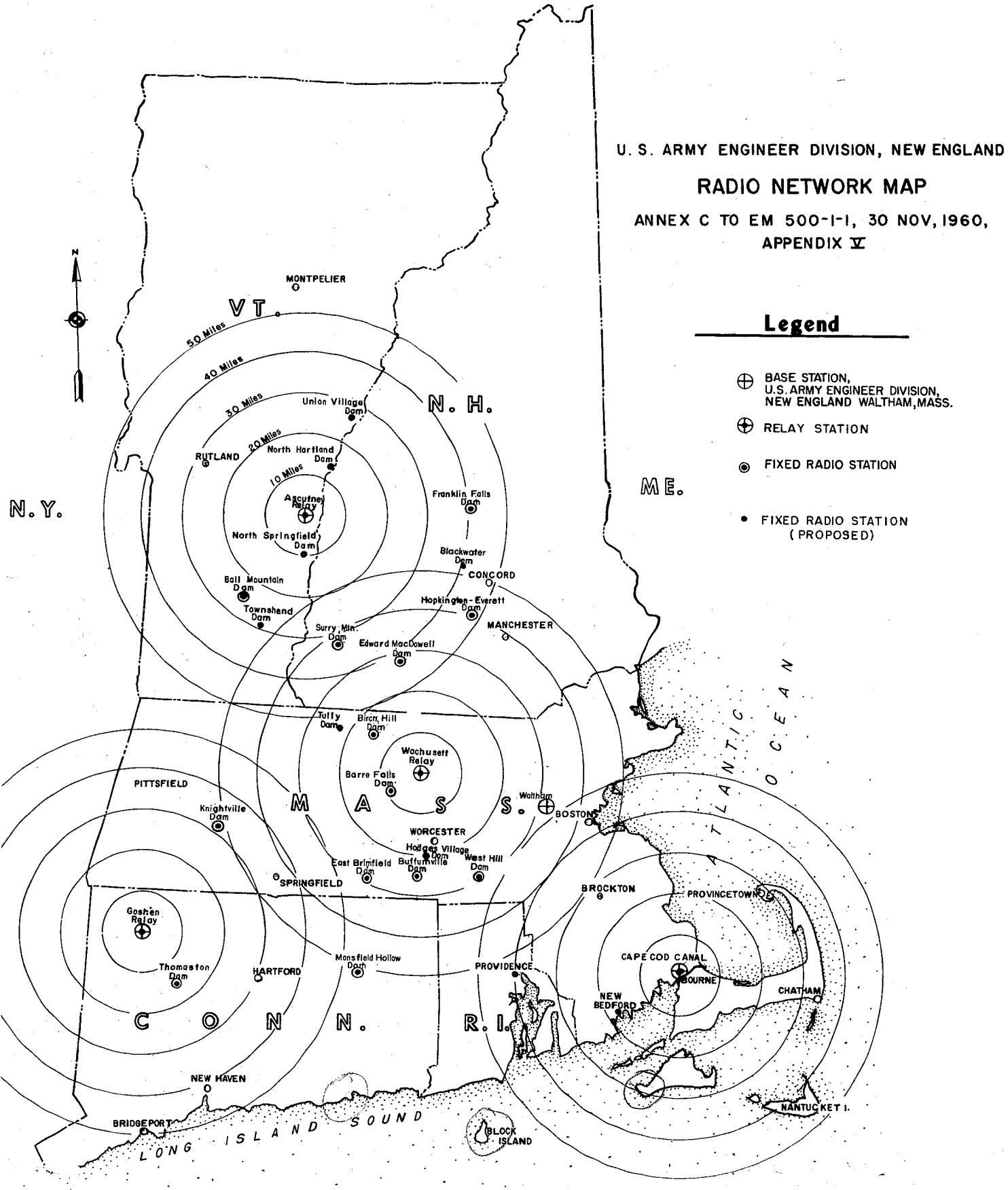

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

# N.E.D. RADIO NETWORK

## HYDROLOGICAL NETWORK
## NAUGATUCK AREA MAP
## SK. NO. R-1

SCALE: 1:250,000 DATE: MAY 30, 1963

SK NO. R-1


U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
RADIO NETWORK MAP
ANNEX C TO EM 500-1-1, 30 NOV, 1960,
APPENDIX V
Legend
BASE STATION, U.S. ARMY ENGINEER DIVISION, NEW ENGLAND WALTHAM, MASS.
RELAY STATION
FIXED RADIO STATION
FIXED RADIO STATION (PROPOSED)
N
MONTPELIER
VT
50 Miles
40 Miles
30 Miles
20 Miles
10 Miles
N. H.
ME.
N. Y.
RUTLAND
Union Village Dam
North Hartland Dam
Ascutney Relay
North Springfield Dam
Ball Mountain Dam
Townshend Dam
Franklin Falls Dam
Blackwater Dam
CONCORD
Hopkinton-Everett Dam
MANCHESTER
Surry Mtn. Dam
Edward MacDowell Dam
Tully Dam
Birch Hill Dam
Wachusett Relay
Barre Falls Dam
PITTSFIELD
Knightville Dam
M A S S.
Waltham
BOSTON
WORCESTER
Hodges Village Dam
East Brimfield Dam
Buffumville Dam
West Hill Dam
SPRINGFIELD
ATLANTIC OCEAN
BROCKTON
PROVINCETOWN
Goshen Relay
Thomaston Dam
HARTFORD
Mansfield Hollow Dam
PROVIDENCE
CAPE COD CANAL
BOURNE
CHATHAM
NEW BEDFORD
C O N N.
R. I.
NEW HAVEN
BRIDGEPORT
LONG ISLAND SOUND
BLOCK ISLAND
NANTUCKET I.

## APPENDIX A

### 1. New England Division Hydrologic Reporting Network -

#### a. General -

Since the disasterous floods in 1955, the New England Division has constructed or has in final design 25 new flood control reservoirs in addition to nine completed prior to 1955, and six hurricane protection projects. Regulation of the flood control reservoirs and the hurricane projects which have navigation gates is the responsibility of the Reservoir Regulation Section. At present, all hydrologic data are obtained either by visual inspection by field observers or telephone. In the New England area, flood control projects are located in five different major river basins and along the southern New England coast. During flood periods, hydrologic data from about 100 stations are received. It is important to record the data in a very short period of time. During major floods, expecially those associated with hurricanes, vital hydrologic data may not be available because either telephone lines are broken or roads leading to key index stations are impassable. The New England Division, recognizing these weaknesses, investigated other means of collecting hydrologic data. Use of radio appears to be the most reliable and fastest means of obtaining the data. Experience gained in the Hydrologic Reporting Network in the Naugatuck River Basin will be used to improve other river basin networks and tidal networks that are in the planning stage. Table V lists the approximate number of radio gages that are presently contemplated for the other river basins and coastal stations. It is estimated that the entire hydrologic radio network may cost about one half million dollars.

### 2. New England Division Radio Network -

#### a. General -

The NED Radio Network, of which the Hydrologic Reporting Network will become a part, came into being in 1957 as a result of the loss of communications during the disasterous floods of 1955. The existing network consists of a 160 mc repeater relay station at Mt. Wachusett, 16 fixed stations, 14 mobile stations and 3 emergency transportable trailer stations. In addition, a separate local network is in existence in the Cape Cod area consisting of 3 fixed stations, 4 mobile stations and 7 ship stations. This facility has been found to be inadequate to perform the normal reservoir regulating, normal operating and emergency disaster operating functions required of it. Consequently, it is now being expanded.

## TABLE V

## PROPOSED RADIO GAGING STATIONS

| River Basin | River | Pool | Precipitation | Tide |
|---|---|---|---|---|
| Connecticut | 16 | 2 | ---- | ---- |
| Thames | 4 | ---- | ---- | ---- |
| Blackstone | 3 | ---- | ---- | ---- |
| Merrimack | 10 | ---- | 2 | ---- |
| Naugatuck | 3 | 7 | 1 | ---- |
| Coastal | ---- | ---- | ---- | 6 |
| TOTAL . . . . . | 36 | 9 | 3 | 6 |

b. Capability of Present Network -

The present network provides voice communication between any two stations, fixed or mobile. It is, in effect, a party line system permitting only one conversation at a time but allowing all stations to monitor any transmission.

c. Capability of Proposed Network -

The proposed network (See Radio Network Map) will provide two-channel selection in each relay area, two-channel relay to relay tie or two-channel relay to headquarters tie except for Cape Cod link. These selections will allow a maximum of eight simultaneous transmissions and a minimum of two.

The maximum number of transmissions will occur when each of the four relay areas are operating as independent local networks. This selection will allow two simultaneous transmissions in each local area, one through the repeater and one point to point.

The minimum number of transmissions will occur when each channel is selected (or connected) for "all call" or party line operation.

With the proposed network, it will be possible in the event of relay damage, to transmit directly mobile to mobile or mobile to fixed station at reduced range and efficiency.

d. Construction Stages -

Expansion of the network will be accomplished in several stages, each adding to the present network in an orderly manner, until the proposed network has been achieved. These stages, in sequence, are as follows:

(1) Wachusett to Goshen Link -

This reach is now being installed as a 400 mc, 2-channel, multiplexed link, and will expand our present party line network into the Goshen, Connecticut area. The equipment installed, however, will have the required capacity to serve the proposed network without modification.

(2) Wachusett to Waltham Link -

This reach will be installed as a 1700 mc, 10-channel, multiplexed link, with a network control console. This installation will expand our present party line system into two-channel capability to Wachusett and Goshen, and will also release two existing 160 mc base stations that, with minor modification, can be used to provide the second channel capability in the Wachusett and Goshen relay areas. Our network will now allow four simultaneous transmissions.

The network control console will have provisions for visual and audio monitoring of ten transmission channels, five remote pick-up satellites and a remote hydrological read-out station. Provisions will be made to perform the following switching:

(a) Manually connect any NED satellite to Channel A or B of any one relay.

(b) Manually connect any NED satellite to Channel A or B of all relays.

(c) Manually connect any two relays on Channel A only.

(d) Automatically connect Channel B of Relay B, G or A, or all three to read-out stations by hydro tone code signal.

(3) Naugatuck River Basin Hydrological Reporting Network -

Since the Waltham to Goshen reach would now have two-channel capability, the hydrological reporting function can now be added without jeopardizing our audio capability. This network will pre-empt audio channel B during data transmission periods only.

(4) Wachusett to Ascutney Link -

This reach will be installed as a 400 mc, 2-channel, multiplexed link and will expand our two-channel network into the Ascutney area. Our network will now allow six simultaneous transmissions. Building construction for this reach was advertised for bids in October 1963 with construction scheduled for completion in August 1964.

(5) Wachusett to Buzzards Bay Link -

This reach will be installed as a 150 mc, single channel link and will expand our network into the Cape Cod area. Tests have indicated that 400 mc signal path for this link might be undependable; consequently 150 mc was selected. Because at 150 mc wide band transmission cannot be approved, and because traffic to and from this link is expected to be light, only single channel capability to Waltham will be installed. The Cape Cod area will, however, have 2-channel capability within its relay area. Our network will now allow eight simultaneous transmissions.

(6) New England Division Hydrological Reporting Network -

Since our two-channel audio network is now complete, the hydrological reporting function can now be added to each relay area without jeopardizing our audio capability.